

# CHAPTER IV - SUMMARY OF FORECAST VERIFICATION

## 1. ANNUAL FORECAST VERIFICATION

### a. Western North Pacific

The positions given for warning times and those at the 24-, 48-, and 72-hour forecast times were verified against the post-analysis best track positions at the same valid times. The resultant vector and right angle errors (illustrated in Fig. 4-1) were then calculated for each tropical cyclone and are presented in Table 4-1. Table 4-2 provides the frequency distributions of vector errors for 24-, 48-, and 72-hour forecasts on all 1981 tropical cyclones in the western North Pacific. A summation of the mean errors, as calculated for

all tropical cyclones in each year, is shown in Table 4-3 for comparative purposes. The data in this table is not to be confused with that presented in previous years where the sample was restricted to cyclones that reached typhoon intensity and then had the forecast errors calculated only for that portion of the life-cycle when winds were greater than 35 kt (last published as Table 5-1, 1977 Annual Typhoon Report). A comparison of the results using the truncated data set and these obtained for all tropical cyclones can be seen directly in Table 4-4. The annual mean vector errors are graphed in Fig. 4-2.

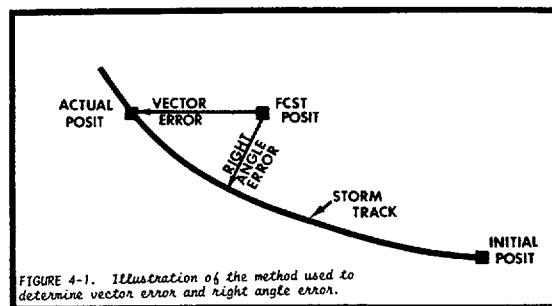


FIGURE 4-1. Illustration of the method used to determine vector error and right angle error.

TABLE 4-1. FORECAST ERROR SUMMARY FOR THE 1981 WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES (ERRORS IN NAUTICAL MILES)

	WARNING			24 HOUR			48 HOUR			72 HOUR		
	POSIT ERROR	RT ANGLE ERROR	WRNGS									
1. FREDA	24	16	22	106	87	19	222	144	14	369	138	9
2. GERALD	40	27	18	161	104	15	289	212	11	426	368	7
3. HOLLY	22	12	30	86	36	29	187	38	29	284	46	29
4. IKE	31	20	21	177	120	15	276	131	7	520	234	1
5. JUNE	19	11	22	119	62	18	227	108	13	196	88	5
6. KELLY	25	18	20	128	110	16	263	242	9	354	347	2
7. LYNN	26	14	19	104	34	14	102	55	10	138	88	4
8. MAURY	54	34	9	140	99	5	215	81	1			
9. NINA	11	4	4									
10. OGDEN	23	14	20	91	46	14	208	93	9	670	477	3
11. TD-11	90	50	7	188	113	3						
12. PHYLLIS	51	43	5	174	87	3						
13. ROY	22	16	19	163	125	15	239	140	8	200	85	4
14. SUSAN	25	17	19	188	147	14	303	254	5	131	106	2
15. THAD	27	21	29	155	73	26	234	129	22	335	183	18
16. VANESSA	31	20	8	184	143	5	354	49	1			
17. WARREN	32	20	10	65	40	6	82	64	2			
18. AGNES	20	11	25	104	76	21	167	132	17	244	208	12
19. BILL	19	15	17	76	29	13	134	62	8	105	31	3
20. CLARA	23	13	29	80	55	26	177	134	22	226	174	18
21. DOYLE	17	11	14	149	102	10	269	194	6	494	253	2
22. ELSIE	18	9	31	97	69	27	213	135	23	377	234	19
23. FABIAN	13	11	6	48	43	2						
24. GAY	31	24	35	163	86	32	275	115	27	410	140	24
25. HAZEN	23	12	37	130	73	33	263	114	30	361	171	26
26. IRMA	18	10	33	76	55	29	118	66	25	141	77	21
27. JEFF	33	13	14	188	40	10	429	71	6	747	38	2
28. KIT	17	9	39	134	82	35	291	168	31	603	326	27
29. LEE	21	16	22	100	75	18	112	66	14	90	62	10
ALL FORECASTS	25	16	584	123	75	473	220	119	350	334	168	248

Table 4-2. Frequency distribution of 24-,  
48-, and 72-hour forecast vector errors for  
all significant tropical cyclones in the  
western North Pacific in 1981. (Given in  
10 nm increments)

LOWER LIMIT	24 HR	48 HR	72 HR	LOWER LIMIT	24 HR	48 HR	72 HR
0	9	1	0	560	0	0	1
10	15	5	2	570	0	1	1
20	22	7	2	580	0	1	1
30	18	10	2	590	0	1	4
40	26	5	2	600	0	0	0
50	23	7	4	610	0	0	0
60	30	5	6	620	0	1	3
70	25	6	3	630	0	1	0
80	28	13	11	640	0	0	2
90	33	12	2	650	1	0	1
100	★21	6	5	660	0	0	1
110	24	12	6	670	0	0	0
120	★28	16	7	680	0	0	1
130	29	14	2	690	0	1	2
140	16	13	6	700	0	0	0
150	13	8	4	710	0	2	0
160	12	14	0	720	0	0	1
170	11	12	11	730	0	0	0
180	13	★11	7	740	0	1	1
190	9	14	1	750	0	0	3
200	7	9	5	760	0	0	1
210	13	★9	2	770	0	0	1
220	11	★10	6	780	0	0	1
230	1	9	2	790	0	0	2
240	6	7	7	800	0	0	0
250	6	3	7	810	0	0	0
260	5	3	4	820	0	0	0
270	5	8	7	830	0	0	0
280	1	5	1	840	0	0	0
290	4	10	4	850	0	0	3
300	3	4	3	860	0	0	0
310	2	4	2	870	0	0	0
320	1	6	0	880	0	0	0
330	3	2	2	890	0	0	0
340	8	9	1	900	0	0	0
350	1	2	0	910	0	0	0
360	0	8	4	920	0	0	1
370	2	2	0	930	0	0	0
380	0	5	6	940	0	0	0
390	0	3	5	950	0	0	0
400	2	2	6	960	0	0	1
410	0	2	7	970	0	0	1
420	0	3	1	980	0	0	0
430	0	2	2	990	0	0	0
440	1	3	2	1000	0	0	0
450	0	4	1	1010	0	0	0
460	0	4	1	1020	0	0	0
470	0	1	2	1030	0	0	0
480	0	2	2	1040	0	0	0
490	0	0	1	1050	0	0	0
500	0	1	4	1060	0	0	0
510	0	3	2	1070	0	0	0
520	1	1	5	1080	0	0	0
530	0	3	5	1090	0	0	0
540	0	1	0	1100	0	0	4
550	0	0	3				

★ MEAN VECTOR ERROR (NM)

★ MEDIAN VECTOR ERROR (NM)

TABLE 4-3. ANNUAL MEAN FORECAST ERRORS (NM) FOR THE WESTERN PACIFIC

YEAR	24-HR		48-HR		72-HR	
	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971	111	64	212	118	317	117
1972	117	72	245	146	381	210
1973	108	74	197	134	253	162
1974	120	78	226	157	348	245
1975	138	84	288	181	450	290
1976	117	71	230	132	338	202
1977	148	83	283	157	407	228
1978	127	75	271	179	410	297
1979	124	77	226	151	316	223
1980	126	79	243	164	389	287
*1981	123	75	220	119	334	168

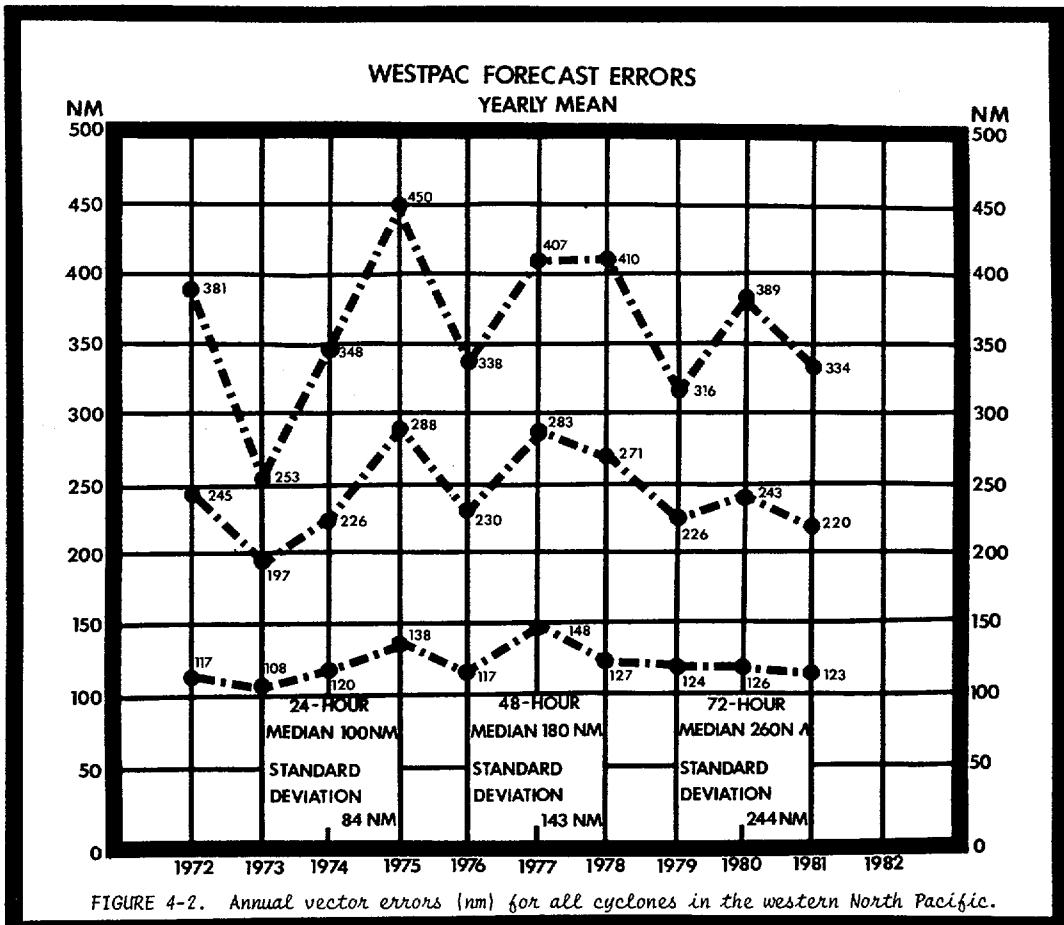
\*The technique for calculating right angle error was revised in 1981, therefore, no attempt should be made to correlate 1981 data with previous years.

TABLE 4-4 ANNUAL MEAN FORECAST ERRORS (NM) FOR WESTERN NORTH PACIFIC

YEAR	24-HR		48-HR		72-HR	
	<u>**ALL</u>	<u>*TYPHOON</u>	<u>ALL</u>	<u>*TYPHOON</u>	<u>ALL</u>	<u>*TYPHOON</u>
1950-58		170				
1959		**117		**267		
1960		**177		**354		
1961		136		274		
1962		144		287		476
1963		127		246		374
1964		133		284		429
1965		151		303		418
1966		136		280		432
1967		125		276		414
1968		105		229		272
1969		111		237		349
1970	104	98	190	181	279	272
1971	111	99	212	203	317	308
1972	117	116	245	245	381	382
1973	108	102	197	193	253	245
1974	120	114	226	218	348	351
1975	138	129	288	279	450	442
1976	117	117	230	232	338	336
1977	148	140	283	266	407	390
1978	127	120	271	241	410	459
1979	124	113	226	219	316	319
1980	126	116	243	221	389	362
1981	123	117	220	215	334	342

\*FOR TYPHOONS ONLY WHILE WINDS OVER 35 KT

\*\*FORECAST POSITIONS NORTH OF 35°N WERE NOT VERIFIED



b. North Indian Ocean Area

Forecast positions at warning, 24-, 48-, and 72-hour valid times were verified for TC 27-81, TC 29-81, and TC 31-81 by the same methods used for the western North Pacific. It should be noted that due to the low number of Indian Ocean tropical cyclones,

the error statistics should not be taken as representative of any trend. Table 4-5 is the forecast error summary for the three cyclones and Table 4-6 contains the annual average of forecast errors back through 1971. Vector errors are plotted in Figure 4-3. Seventy-two-hour forecast errors were evaluated for the first time in 1979.

TABLE 4-5. FORECAST ERROR SUMMARY FOR THE 1981 NORTH INDIAN OCEAN SIGNIFICANT TROPICAL CYCLONES.

CYCLONE	WARNING			24 HOUR			48 HOUR			72 HOUR		
	POSIT ERROR	RT ANGLE ERROR	# WRNGS									
TC 27-81	41	27	13	135	106	9	221	155	5	83	25	1
TC 29-81	28	12	12	69	35	8	172	110	4			
TC 31-81	17	14	16	115	55	12	151	67	8	225	85	4
ALL FORECASTS	28	17	41	109	65	29	176	103	17	197	73	5

TABLE 4-6. ANNUAL MEAN FORECAST ERRORS FOR THE NORTH INDIAN OCEAN (the Arabian Sea was not included prior to 1975).

YEAR	24-HR		48-HR		72-HR	
	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971	232	-	410	-	-	-
1972	224	101	292	112	-	-
1973	182	99	299	160	-	-
1974	137	81	238	146	-	-
1975	145	99	228	144	-	-
1976	138	108	204	159	-	-
1977	122	94	292	214	-	-
1978	133	86	202	128	-	-
1979	151	99	270	202	437	371
1980	115	73	93	87	167	126
*1981	109	65	176	103	197	73

\*The technique for calculating right angle error was revised in 1981, therefore, no attempt should be made to correlate 1981 data with previous years.

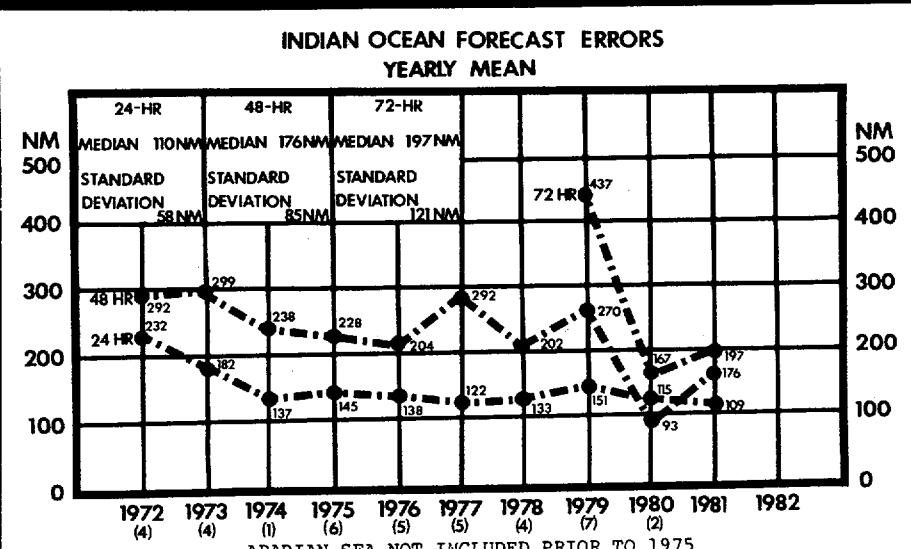


FIGURE 4-3. Annual mean vector errors (nm) for all cyclones in the north Indian Ocean.

## 2. COMPARISON OF OBJECTIVE TECHNIQUES

### a. General

Objective techniques used by JTWC are divided into four main categories:

- (1) climatological and analog techniques;
- (2) extrapolation;
- (3) steering techniques;
- (4) dynamic models

The analog techniques provide three movement forecasts, i.e. forecasts for straight moving cyclones, recurring cyclones, and a combination forecast based upon the tracks of straight, recurving, and all other cyclones that do not meet the specific criteria of those two categories. All objective techniques except one of the dynamic model modes, were executed using operational data available prior to warning time. The automatically run version of one of the dynamic models was initialized from analysis fields that are not available prior to warning times. These objective aids are usually received within 2 to 5 hours of a specific warning time.

### b. Description of Objective Techniques

(1) CLIM -- A climatological aid providing 24-, 48-, and 72-hour tropical cyclone forecast positions, and intensity changes, based upon the initial position of the system. The output is based upon data records from 1945 to 1973.

(2) TYAN 78 -- An updated analog program which combines the earlier versions TYFN 75 and INJAH 74. The program scans history tapes for cyclones similar (within a specified acceptance envelope) to the current cyclone. For the NW Pacific region three types of position and intensity forecasts are provided at 24-, 48-, and 72-hour intervals (e.g. straight, recurve, and combined). For all other regions of the JTWC AOR, types of track are not specified.

(3) EXTRAPOLATION -- A track connecting the 12-hour old preliminary best track position and the current position which is then extrapolated to 24 and 48 hours.

(4) HPAC -- 24- and 48-hour forecast positions are derived by merely connecting the mid-points of straight lines which were drawn to connect these positions on the EXTRAPOLATION and CLIM tracks, respectively.

(5) BPAC -- A program used with a Texas Instrument's (TI-59) calculator system which generates 12 to 72 hr forecast positions. These forecasts are based on blending the past motion of the tropical cyclone

with the CLIM forecast positions. The blending routine gives less weight to persistence at each succeeding forecast interval.

(6) CYCLOPS -- An updated version of the HATTRACK/MOHATT steering program which can provide steering forecasts at the 1000, 850, 700, 500, 400, 300, and 200 mb levels. The program can be run in the modified (includes a 12-hour persistence bias) or unmodified versions applied to either analysis or prognostic fields. The program advects a point vortex on a pre-selected analysis and/or smoothed prognostic field at designated levels in 6-hour time steps through 72 hours. In the modified version, the program uses the previous 12-hour history position to compute the 12-hour forecast error and applies a bias correction to the forecast positions. In 1981, only the modified version, in the prognostic mode for the 500 mb level was verified.

(7) TCM -- The dynamic Tropical Cyclone Model (TCM) is a coarse mesh (220 km) primitive equation model. The digitized cyclone warning position is bogused into the 850 mb wind and temperature fields of the FLENUMOCEANCEN Global Bands Analysis. Hemisphere forecast data are used on the boundaries. Two versions are currently run: The OTCM runs from forecasts fields and is available via ARQ mode; the TCMO version was mentioned in a. above.

(8) NTCM -- A "nested" primitive equation tropical cyclone model which is initialized on FLENUMOCEANCEN 12-hour forecast fields. The model covers a limited, but relocatable, tropical domain with three layers in the vertical. The finer scale or "nested" grid covers a 1200 x 1200 km<sup>2</sup> area with a 41 km grid spacing and moves to keep a 850 mb vortex in its center. This grid is integrated with a coarser channel model grid with a grid spacing of 205 km over a 6400 x 4700 km<sup>2</sup> domain. Once initialized, the model runs independent of the remaining FLENUMOCEANCEN forecast fields. The NTCM is available by ARQ for 0000Z and 1200Z forecast fields only.

### c. Testing and Results

A comparison of selected techniques is included in Table 4-7 for all western North Pacific cyclones and in Table 4-8 for Indian Ocean Cyclones. In these Tables, "X-AXIS" refers to techniques listed horizontally across the top, while "Y-AXIS" refers to techniques listed vertically. The example in Table 4-7 compares CY50 to TCMO, i.e. in the 138 cases available for comparison, the average vector at 24-hours was 137 nm for CY50 and 117 nm for TCMO. The difference of -18 nm is shown in the lower right. (Differences are not always exact due to computational round off).

## STATISTICS FOR YEAR 24 HR FCSTS

	JTWC	RECR	STRA	TOTL	CY50	NTCM	TCMO	BPAC	CLIM	XTRP	HPAC
JTWC	473 123										
	123 0										
RECR	407 124	414 133									
	132 8	133 0									
STRA	369 120	378 129	375 138								
	139 18	138 9	138 0								
TOTL	414 123	414 133	375 138	422 132							
	132 9	131 0	127 -18	132 0							
CY50	410 123	384 133	348 140	392 133	420 132						
	133 9	131 -1	131 -8	131 -1	132 0						
NTCM	120 113	105 141	94 136	107 152	189 136	122 163					
	163 45	160 19	155 18	163 11	164 28	163 0					
TCMO	153 120	136 133	124 137	138 144	138 137	74 157	156 120				
	120 0	119 -13	116 -20	121 -22	117 -18	120 -36	120 0				
BPAC	437 123	396 132	356 137	402 131	397 131	117 163	148 119	447 124			
	124 2	123 -8	118 -18	124 -6	125 -5	121 -41	123 4	124 0			
CLIM	462 123	413 133	374 138	421 133	414 132	122 163	153 119	447 124	473 160		
	160 36	158 25	151 12	159 27	160 29	155 -7	158 39	159 35	160 0		
XTRP	448 123	402 133	362 139	409 133	409 133	119 163	152 118	437 124	454 161	460 132	
	132 9	132 0	128 -18	132 0	133 0	131 -31	127 9	132 7	133 -28	132 0	
HPAC	443 123	401 133	361 139	408 133	403 133	119 163	150 117	437 124	454 161	454 133	454 124
	124 1	123 -9	117 -22	124 -8	125 -7	117 -45	121 4	123 0	124 -36	124 -7	124 0

NUMBER OF CASES	X-AXIS TECHNIQUE ERROR
	Y-AXIS TECHNIQUE ERROR
	ERROR DIFFERENCE Y-X

## STATISTICS FOR YEAR 48 HR FCSTS

	JTWC	RECR	STRA	TOTL	CY50	NTCM	TCMO	BPAC	CLIM	XTRP	HPAC
JTWC	350 220										
	220 0										
RECR	396 221	329 261									
	235 34	261 0									
STRA	291 222	303 259	309 287								
	288 66	288 30	287 0								
TOTL	315 221	329 261	309 287	338 261							
	235 34	258 -2	253 -33	261 0							
CY50	298 217	296 259	278 283	305 258	323 323						
	325 108	327 69	333 50	325 67	323 0						
NTCM	92 200	86 236	81 307	88 260	86 308	100 275					
	279 79	267 32	262 -44	280 20	279 -28	275 0					
TCMO	111 223	100 271	101 291	111 274	106 340	61 279	123 219				
	214 -8	205 -65	197 -93	216 -57	220 -119	236 -42	218 0				
BPAC	325 219	313 258	293 285	321 258	307 325	98 273	119 218	355 253			
	246 28	253 -4	251 -33	255 -2	252 -73	238 -34	255 37	253 0			
CLIM	345 221	328 261	308 287	337 261	321 323	100 275	122 217	355 253	375 306		
	383 92	305 45	303 16	308 46	306 -16	295 19	308 83	302 49	306 0		
XTRP	331 223	314 262	293 292	322 263	307 326	98 276	118 216	340 255	354 311	356 289	
	295 61	287 25	288 -3	289 26	288 -37	286 10	292 76	288 33	290 -20	289 0	
HPAC	330 223	313 261	292 292	321 263	305 326	98 276	117 215	340 255	354 311	354 290	354 248
	244 21	245 -15	242 -49	240 -15	246 -79	239 -36	249 35	245 -9	248 -62	248 -41	248 0

JTWC - OFFICIAL JTWC FORECAST  
 STRA - STRAIGHT (TYAN 78)  
 RECR - RECURVE (TYAN 78)  
 COMB - COMBINED (TYAN 78)  
 CY50 - CYCLOPS 500-MB PROG  
 TCMO - TROPICAL CYCLONE MODEL (ONE-WAY)  
 CLIM - CLIMATOLOGY  
 XTRP - 12-HOUR EXTRAPOLATION  
 HPAC - MEAN OF XTRP AND CLIMATOLOGY

## STATISTICS FOR YEAR 72 HR FCSTS

	JTWC	RECR	STRA	TOTL	CY50	NTCM	TCMO	BPAC	CLIM	
JTWC	248 334									
	334 8									
RECR	222 340	253 420								
	419 79	420 0								
STRA	208 346	232 425	236 412							
	418 71	415 -9	412 0							
TOTL	226 337	253 420	236 412	260 421						
	424 87	420 0	414 2	421 0						
CY50	202 322	219 428	206 401	226 418	239 570					
	613 280	586 158	598 197	579 161	570 0					
NTCM	60 309	65 498	62 486	67 439	63 553	76 441				
	428 119	424 16	419 -66	447 9	451 -101	441 0				
TCMO	68 322	69 428	66 412	72 452	65 624	35 449	88 309			
	293 -29	300 -127	279 -132	313 -137	310 -313	400 -40	369 0			
BPAC	229 350	240 420	222 415	246 421	227 575	74 441	76 309	271 393		
	392 62	395 -24	390 -23	396 -23	395 -179	384 -56	397 88	393 0		
CLIM	245 334	253 420	236 412	260 421	239 570	76 441	80 309	271 393	289 450	
	457 123	456 36	451 39	457 35	450 -111	416 -23	456 147	447 54	450 0	

TABLE 4-7  
ERROR STATISTICS FOR THE WESTERN NORTH PACIFIC FOR 1981

STATISTICS FOR YEAR			24 HR FCSTS								
JTWC	TOTL	NONE	NONE	CY70	CY50	TCMO	BPAC	CLIM	XTRP	HPAC	
29	109										
109	0										
TOTL	28	112	28	117							
117	5	117	0								
NONE	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0			
NONE	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0			
CY70	27	114	27	121	0	0	0	27	116		
116	2	116	-3		0	0	0	116	0		
CY50	26	117	26	123	0	0	0	26	116	26	
123	7	123	1		0	0	0	123	7	123	
TCMO	18	110	10	115	0	0	0	10	128	9	
214	104	214	99		0	0	0	214	86	126	
BPAC	27	111	27	128	0	0	0	26	117	25	
118	0	110	-9		0	0	0	112	-3	124	
CLIM	28	112	28	117	0	0	0	27	116	26	
117	5	117	0		0	0	0	117	1	121	
XTRP	26	111	26	120	0	0	0	25	117	24	
126	15	126	6		0	0	0	138	13	134	
HPAC	26	111	26	120	0	0	0	25	117	24	
114	3	114	-5		0	0	0	116	0	126	
					0	0	0	121	-4	117	
								-96	114	3	
									114	-5	
									114	-11	
									114	0	

NUMBER OF CASES	X-AXIS TECHNIQUE ERROR	
	Y-AXIS TECHNIQUE ERROR	
Y-AXIS TECHNIQUE ERROR	ERROR DIFFERENCE Y-X	

STATISTICS FOR YEAR			48 HR FCSTS								
JTWC	TOTL	NONE	NONE	CY70	CY50	TCMO	BPAC	CLIM	XTRP	HPAC	
17	176										
176	0										
TOTL	16	167	16	246							
246	79	246	0								
NONE	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0			
NONE	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0			
CY70	17	176	16	246	0	0	0	17	359		
359	182	357	111		0	0	0	359	0		
CY50	16	178	15	250	0	0	0	16	367	16	
414	236	417	166		0	0	0	414	46	414	
TCMO	6	166	5	225	0	0	0	6	375	5	
473	307	447	222		0	0	0	473	98	468	
BPAC	16	176	15	252	0	0	0	16	351	15	
232	55	228	-23		0	0	0	232	-118	232	
CLIM	17	176	16	246	0	0	0	17	359	16	
226	49	212	-33		0	0	0	226	-132	232	
XTRP	15	173	14	266	0	0	0	15	352	14	
293	120	296	30		0	0	0	293	-58	300	
HPAC	15	173	14	266	0	0	0	15	352	14	
253	80	250	-15		0	0	0	253	-98	261	
					0	0	0	233	-239	233	
								253	9	253	
									16	253	
									253	-39	
									253	0	

JTWC - OFFICIAL JTWC FORECAST  
 TY78 - ANALOG (TYAN 78)  
 CY70 - CYCLOPS 700-MB PROG  
 CY50 - CYCLOPS 500-MB PROG  
 TCMO - TROPICAL CYCLONE MODEL (ONE-WAY)  
 XTRP - 12-HOUR EXTRAPOLATION  
 HPAC - MEAN OF XTRP AND CLIMATOLOGY

STATISTICS FOR YEAR			72 HR FCSTS								
JTWC	TOTL	NONE	NONE	CY70	CY50	TCMO	BPAC	CLIM	XTRP	HPAC	
5	197										
197	0										
TOTL	5	197	5	307							
307	110	307	0								
NONE	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0			
NONE	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0			
CY70	5	197	5	307	0	0	0	5	750		
750	553	750	443		0	0	0	750	0		
CY50	4	138	4	354	0	0	0	4	737	4	
909	771	909	555		0	0	0	909	172	909	
TCMO	1	149	1	235	0	0	0	1	876	1	
761	612	761	526		0	0	0	761	-115	761	
BPAC	5	197	5	307	0	0	0	5	750	4	
299	103	299	-6		0	0	0	299	-449	352	
CLIM	5	197	5	307	0	0	0	5	750	4	
349	151	348	41		0	0	0	348	-400	395	
					0	0	0	-513	294	-466	
									348	49	
									348	0	

TABLE 4-8.  
ERROR STATISTICS FOR THE NORTH INDIAN OCEAN  
FOR 1981